RELATIVE ATTRACTIVENESS OF VEGETABLE, ANIMAL AND PETROLEUM OILS FOR THE MEDITERRANEAN FRUIT FLY (CERATITIS CAPITATA WIED.).

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Only a small amount of work has been done by entomologists to determine the relative attractiveness of vegetable, animal and petroleum oils for the Mediterranean fruit fly. Hopper (1907, p. 395) of Western Australia conducted an experiment in which four oils were used to trap the Mediterranean fruit fly. The oils were placed in tins and an examination of the traps 24 hours later gave the following results: "Turpentine:—6 tins used, 1 fly in one, and all the rest empty and dry. Benzine:—8 tins used, one fly in one and 4 in another, all tins dry. Naphtha:—4 tins used, no flies caught, all tins dry. Kerosene:—6 tins used, 149 flies caught (every tin containing some), all tins moist." Since in this experiment, all tins except those containing kerosene were found dry and empty, one would naturally expect that kerosene would attract the most fruit flies.

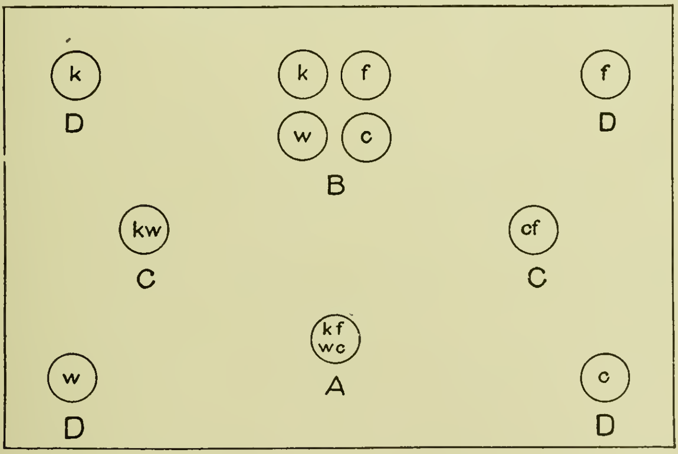
Williams (1907, p. 697) also of Western Australia "carried on an experiment with benzine, naphtha, turpentine, ammoniated tar water, methylated spirits, etc., but in no instance did any of them equal kerosene."

Lounsbury (1908, p. 7) of South Africa tried to ascertain the relative attractiveness of kerosene, turpentine and water for the Mediterranean fruit fly. His experiments were carried on with several hundred fruit flies which were allowed to emerge from infested fruit placed in a cage ($2 \times 1\frac{1}{2} \times 1$ feet) and inside of which were the oils and water. Within one hour, eleven fruit flies visited the turpentine and in three and one half hours seven went to the kerosene and seventeen went to the water. Lounsbury writes, Not unnaturally I got the impression that the fruit flies, "mistook the oil for water and were trapped in attempting to drink or to alight to drink." In experiments III and IV our results with kerosene, turpentine and water are given under field conditions.

Gurney (1910, pp. 5–6) of New South Wales also experimented with a number of oils to trap the Mediterranean fruit fly. He writes: "The following oils, placed in saucers in the orchards, were tried as traps for the adult flies:—Kerosene, citronella, linseed, salad, whale, neatsfoot and fish. The non-success of any of these oils during these seasons may have merely indicated the scarcity of the Mediterranean fruit fly."

In view of the absence of exact data concerning the relative attractiveness of many of the vegetable, animal and petroleum oils for the Mediterranean fruit fly, and since none of the entomologists mentioned gave any record as to whether or not a superabundance of males were captured in the oils, it was decided to carry on a series of tests along this line. In each of the following experiments, kerosene (Star oil about 120° Bé.) was used as a check. The number of fruit flies captured in kerosene compared with the number caught in other oils would give the relative attractiveness of the oils for the Mediterranean fruit fly.

A glance at the following diagram will show the arrangement of



the oil traps in the orchard. A circle represents a single fruit tree and the letter within the circle designates the name of the oil in the trap. In selecting the letters, the first letter of the name of the oil was used, viz:—k = kerosene, c = citronella, w = whale and f = fish oil.

For a description and picture of the oil traps, such as were used in all of the following experiments, we refer the reader to a previous paper (1912, p. 403).

In the first experiment four traps containing either kerosene, fish, whale or citronella oil were wired at the same height in a single large Waialua orange tree (*Citrus aurantium sinense*) represented in the diagram by a circle with the letters k, f, w, and c (Diagram, A). In this same experiment four lemon trees (*Citrus medica limonum*) closely clustered together were each provided with a trap containing one of the above oils (Diagram, B). In each of two navel orange trees (*Citrus aurantium*) situated at some distance from each other, two traps were fastened containing either kerosene or whale oil and citronella or fish oil (Diagram, CC). Lastly, four traps each of which contained one of the four oils, were put in four navel orange trees situated in different sections of the orchard (Diagram, DDDD). The following figures indicate the results of a three days' catch in each oil trap:

EXPERIMENT I.

Trees.	One Waialua Orange.	Four Lemon.	Two Navel Orange.	Four Navel Orange.	Total Males.
Kerosene	123	42	26	70	261
Citronella oil	0	3	0	1	4
Whale oil	0	0	0	0	0
Fish oil	0	0	0	0	0

As there still was a possibility that the volatile parts of the different oils had interfered with one another in the above experiment, it was decided to test out each oil separately in another orchard. A trap containing citronella oil was wired in each of three guava trees (*Psidium guayava pomiferum*), one tropical almond (*Terminalia cattapa*), one bread fruit (*Artocarpus incisa*) and one lime tree (*Citrus medica limetta*). This experiment was continued for a week, at the end of which time the traps were replaced with a clean set containing whale oil. The whale oil was tested out in the same trees for nine days, then the fish oil was substituted for fourteen days and finally kerosene for one day. The results in this experiment were as follows:

EXPERIMENT II.

	Traps.	Days.	Males.
Citronella oil	6	7	49
Whale oil	6	9	0
Fish oil	6	14	2, 2 females.
Kerosene	6	1	138

In the next experiment the relative attractiveness of kerosene, turpentine, cocoanut oil and water for the Mediterranean fruit fly was tested. This experiment was conducted in the first mentioned orchard and the oil traps were arranged as shown in the previous diagram. Since turpentine is very volatile, a man was sent to the orchard several times a day to pour a new supply of this oil into the traps. This experiment was carried on for eight hours during two days with the following results:

EXPERIMENT III.

	Traps.	Hours.	Males.
Kerosene	4	16	172
Turpentine	4	16	8
Cocoanut oil	4	16	0
Water	4	16	0

The same oils were now tested out separately for a period of eight hours on three different days; the water, however, was kept in ten traps wired in citrus trees for a period of thirteen days. The results were as follows:

EXPERIMENT IV.

	Traps.	Hours.	Males.
Kerosene	4	8	41
Turpentine	4	8	2
Cocoanut oil	4	8	0
Water	10	13 days	0

Twelve traps containing vinegar were wired to citrus trees for two days but no fruit flies were captured in these traps. Vanilla extract was also used but gave only negative results.

Experiments in trapping the Mediterranean fruit fly with oils belonging to the naphtha distillate derived from crude petroleum were conducted in two orchards. On account of the volatileness of these oils, the experiments were continued for only eight or nine hours a day, but the traps were never allowed to dry out. The number of traps used, the number of hours each experiment was conducted and the results obtained are as follows:

Naphtha Distillate.

EXPERIMENT V.

	Traps.	Hours.	Males.
Kerosene about 120° Bé.	5	24	81
Gasoline about 86° Bé.	5	24	16

EXPERIMENT VI.

	Traps.	Hours.	Males.
Kerosene about 120° Bé...........	5	16	21
Gasoline about 63° Bé...........	5	16	13

EXPERIMENT VII.

	Traps.	Hours.	Males.
Kerosene about 120° Bé...........	8	18	73
Benzine about 58° Bé...........	8	18	53

EXPERIMENT VIII.

	Traps.	Hours.	Males.
Kerosene about 120° Bé...........	6	16	53
Distillate about 48° Bé...........	6	16	55

EXPERIMENT IX.

	Traps.	Hours.	Males.
Kerosene about 120° Bé...........	4	24	97
Gasoline about 86° Bé...........	4	24	34
Benzine about 58° Bé...........	4	24	91

EXPERIMENT X.

	Traps.	Hours.	Males.
Gasoline about 86° Bé............	7	8	15
Benzine about 58° Bé............	7	8	53

It is evident from these experiments that gasoline (about 86° Bé.) attracts a smaller number of fruit flies than kerosene or benzine (Experiments V, IX, X). Distillate (about 48° Bé.) was the only oil which attracted more fruit flies than kerosene (Experiment VIII). The experiment with the distillate and kerosene was carried on for a period of eight hours during two days and the catch for each day may be worth recording. The first day the results were: kerosene 31, distillate 38, a difference of 7 in favor of the distillate; but the second day the ratio was: kerosene 22, distillate 17, a difference of 5 in favor of the kerosene. The experiment with the distillate must be repeated, however, in order that definite conclusions may be drawn concerning these oils.

In the next experiment the oils classed under the burning oil distillate were tested in traps which were wired to fruit-bearing mango trees. The traps were shifted about in the trees from time to time but this did not have any marked effect on the number of specimens captured in the different oils. This experiment was carried on for a period of sixteen days and the folowing figures indicate the results obtained:

Burning Oil Distillate.

EXPERIMENT XI.

	Traps.	Days.	Males.
Export oil about 110° Bé	1	16	190
Kerosene about 120° Bé	1	16	552
Mineral seal oil	1	16	80
Colza burning oil	1	16	10
Perfection signal oil	1	16	1

It is evident from the results of this experiment that the heavy burning oils, such as mineral seal, colza burning and perfection signal, do not attract as many fruit flies as kerosene and export oil. In these three heavier burning oils the volatile part which attracts the Mediterranean fruit fly must be present in still less quantities than in gasoline (about 86° Bé.).

In the following experiment two of the lubricating oils were tested and the results were as follows:

Lubricating Oil Distillate.

EXPERIMENT XII.

	Traps.	Days.	Males.
Kerosene about 120° Bé	4	3	86
Renown engine oil F. 375	4	3	6
Atlantic red engine oil F. 350	4	3	0

Since all of the oils classified under the naptha distillate, burning oil distillate and lubricating oil distillate are obtained from crude petroleum, it was reasonable to suppose that the crude oil itself would attract the fruit fly. The results with this oil were as follows:

EXPERIMENT XIII.

	Traps.	Days.	Males.
Kerosene about 120° Bé	4	3	60
Crude petroleum	4	3	41

In the following table the relative attractiveness for the Mediterranean fruit fly of animal and vegetable oils and oils derived from crude petroleum is given, the attractiveness of kerosene for the fruit fly being taken as 100 per cent.

TABLE I.

		Experiment.	Per Cent.
Vegetable oils	Citronella oil	I	1
	Turpentine	III and IV (average)	.04
	Cocoanut oil	III and IV (average)	0
Animal oils	Whale oil	I	0
	Fish oil	I	0
Naptha distillate	Distillate about 48° Bé	VIII	103
	Benzine about 58° Bé	VII and IX (average)	82
	Gasoline about 63° Bé	VI	61
	Gasoline about 86° Bé	V and IX (average)	27
Burning oil distillate	Export oil about 110° Bé	XI	34
	Star oil (kerosene) about 120° Bé	XI	100
	Mineral seal oil	XI	14
	Colza burning oil	XI	1
	Perfection signal oil	XI	.1
Lubricating oil distillate	Renown engine oil F. 375	XII	6
	Atlantic red engine oil F. 350	XII	0
	Crude petroleum	XIII	68

It is evident that the attraction of the Mediterranean fruit fly to these oils was confined almost entirely to the male sex. Female flies were present in these orchards because hundreds were caught by sweeping with an insect net among the fruit trees. Trapping the pest with kerosene was carried on for a period of eight months in the Hawaiian Islands in connection with other experiments and the results show that of every 1000 fruit flies captured only 3 on an average were females, the remainder being males.

Why should enormous numbers of male fruit flies and only a few females be captured in certain oils? Concerning the behavior of *Dacus zonatus* towards citronella oil, Howlett (1912, p. 413) writes: "Since the reaction was confined to the male sex and did not appear to be in any way connected with feeding habits, it seemed most reasonable to suppose that the smell might resemble some sexual odor of the female which in natural conditions served to guide the male to her." This is, in substance, a view which we also expressed to a number of entomologists and mentioned in a paper read before the Agricultural Seminar in Honolulu on January 11, 1912, to explain the behavior of the male Mediterranean fruit fly towards kerosene. Howlett believes that "the smell is in all probability perceived by means of the antennæ," for, after he had carefully amputated these "at the base of the second joint," none of the mutilated insects were attracted to the oil of citronella.

If it is true that certain oils give off an odor which resembles that emitted by the female fruit flies to attract the opposite sex, then how would the fact be explained that a few females are usually caught in the oils? We should have to assume that the specialized sense organs present in the males to locate the females are absent in the latter. We would then be forced to conclude that the females were not attracted to the petroleum oils, but came within the sphere of influence of the oil by accident, became stupefied and dropped into the oil. There is, of course, the possibility that the reaction of the male Mediterranean fruit fly towards some volatile part of the petroleum oils may be a positive chemotaxis "not representing the sexual smell of the female," a possibility to which Howlett also calls attention in the behavior of *Dacus zonatus* towards citronella oil.

The behavior of the Mediterranean fruit flies was occasionally observed in the neighborhood of the traps. In some instances, fruit flies remained at rest on the inside of the pans for long periods of time as if stupefied by the volatile parts of the oil. In other cases, the flies would walk along the inside of the pan for a time, then take wing and fly up to a neighboring leaf or twig, or in their apparently dizzy, zigzag flight over the surface of the petroleum oils they would plunge into the oil and generally cease all activity noticeable to the naked eye in less than half a minute.

It certainly is peculiar that the male Mediterranean fruit flies plunge into the petroleum oils to their own destruction. The flies may be attracted to the oil as a result of a chemotaxis due to one or more hydrocarbons or to the impurities of the petroleum oils, such as the sulphur constituents or nitrogenous products. Small quantities of sulphides are detected by the human nose and it may be possible that the minutest traces are perceived by the fruit flies. Furthermore, sulphides have recently been found within the bodies of insects. Again, the hydro-carbons of the oil may act as an anesthetic, and stupefy the insects whenever they remain within their influence. It is known that the volatile parts of gasoline, for instance, have a stupefying effect upon animals. According to a scientist connected with the Standard Oil Company, cases are on record where men, who had opened barrels of gasoline, were suddenly overcome by the fumes and plunged "head first" into the oil. Large gasoline tanks which have been recently emptied are dangerous for men to go into, and require about twenty-four hours of ventilation before they are safe for a human being to enter.

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ON THE MISUSE OF THE TERMS PARAPTERON, HYPOPTERON, TEGULA, SQUAMULA, PATAGIUM AND SCAPULA.[1]

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One of the terms most frequently misapplied by writers on insect morphology, is the designation parapteron. Each of the lined areas in fig. 2 (*i. e., pa, pas, prs. aba, pba,* and *aes*) as well as the sclerites *sur, npt,* and *sa* have been designated as the "parapteron." Since it is quite evident that all of these cannot be so termed, without creating confusion, it may be of some interest to attempt to establish the correct application of the designation parapteron, as intended by its author.

[1] Contribution from the Entomological Laboratory of the Massachusetts Agricultural College, Amherst, Mass.